ATTACHMENT 25

LTWP Detailed Design Report - Appendix J - Preliminary Blast Assessment

Rev 1
April 24, 2026

Appendix J

Preliminary Blast Assessment Report

Specialists in Explosives, Blasting and Vibration
Consulting Engineers

December 15, 2023

Adaptive Baseline Geotechnical Ltd.
17 Industrial Way
Elmsdale, Nova Scotia
B2S 2L6

Attention: Mr. Ian Crawford

Subject: Long Term Water Program – Raw Water Supply and Storage Project Blasting Assessment Iqaluit, Nunavut

Dear Mr. Crawford,

In accordance with your request, Explotech Engineering Ltd. (Explotech) has undertaken a review of the available project documents and details for the Long Term Water Program – Raw Water Supply and Storage Project in Iqaluit, Nunavut. Given the lack of geotechnical information available at the time of this report, we have assumed that blasting may be required at any point within the outlined project footprint. Explotech has not completed a site visit at the time of submitting this report. All details in the report are based solely on the documentation provided to Explotech from the client. This report summarizes our analysis and recommendations.

Project Details

The Long Term Water Program – Raw Water Supply and Storage Project involves the construction of a 4.1km pipeline between The Unnamed Lake, a catchment located approximately 4.5km Northeast of the city of Iqaluit, to the city's current reservoir and water source, Lake Geraldine. The intention of this pipeline is to provide additional drinking water to the city of Iqaluit to support the growing population. A reservoir will be constructed adjacent to Lake Geraldine in order to store this additional drinking water supply. Blasting for this project will be completed primarily with the use of traditional surface blasting techniques. Marine blasting operations may be required should dredging of the existing lakes in the reservoir be deemed necessary at a later date.

Existing Conditions

The project footprint is located approximately 2km Northeast of the Iqaluit city centre. The areas surrounding the project footprint are largely vacant with the closest structures lying approximately 500m from the closest point of the proposed reservoir. Numerous waterbodies are scattered throughout the project site but the largest waterbody identified is Lake Geraldine, the city's current water supply reservoir, which has a maximum depth of 22m. Fish habitat and potential for fish spawning has been identified in select waterbodies surrounding the project site. In addition, the Lake Geraldine Dam is located to the Southwest of the proposed project site. Table 1 below demonstrates the distance from the project site receptors of interest for the purpose of the blast impact assessment:

Receptor	Distance to Receptor (m)	Direction from Blasting Footprint Limits
Residential Structures on Road to Nowhere	~500m	South
Residential Structures in Plateau Subdivision	~1050m	West
Lake Geraldine Dam	~550m	Southwest

Table 1: Closest Receptors to the Project Footprint

Blast Mechanics and Derivatives

The detonation of explosives within a borehole results in the development of very high gas and shock pressures. This energy is transmitted to the surrounding rock mass, crushing the rock immediately surrounding the borehole (approximately 1 borehole radius) and permanently distorts the rock to several borehole diameters (5-25, depending on the rock type, prevalence of joint sets, etc).

The intensity of this stress wave decays quickly so that there is no further permanent deformation of the rock mass. The remaining energy from the detonation travels through the unbroken material in the form of a pressure wave or shock front which, although it causes no plastic deformation of the rock mass, is transmitted in the form of ground vibrations. In addition to the ground vibrations, air overpressure and/or water overpressure are generated through the direct action of the explosive venting through cracks in the rock or through the indirect action of the rock movement. In either case, the result is a pressure wave which either travels through the water (measured in kilopascals (kPa)) or through the air (measured in linear decibels (dB(L)).

Environmental Effects and Applicable Limits

Ground Vibrations and Applicable Limits

Recent years have seen an almost universal adoption of blast vibration standards developed by the United States Bureau of Mines (USBM). These standards have been utilized as the basis for the development of blast and vibration control regulations by the overwhelming majority of Government and private organizations across North America.

Particle velocity is the descriptor of choice when dealing with vibrations because of its superior correlation with the appearance of cosmetic cracking. While particle velocities provide one measurement statistic, structural responses to varied frequency necessitates the inclusion of frequency analysis in all vibration measurement. As such, the USBM criteria developed utilizes a graded scale incorporating reduced permissible particle velocities at reduced dominant frequencies (refer to graphical analysis Figure 1). This is not to say that damage automatically occurs once these levels are breached and, in fact, threshold damage would not occur in the average residence until ground vibrations reached significantly higher intensities than those listed above. The standard criteria have been set at very conservative levels in an effort to restrict adverse public response as opposed to strictly alleviating possibility for structural and cosmetic damage.

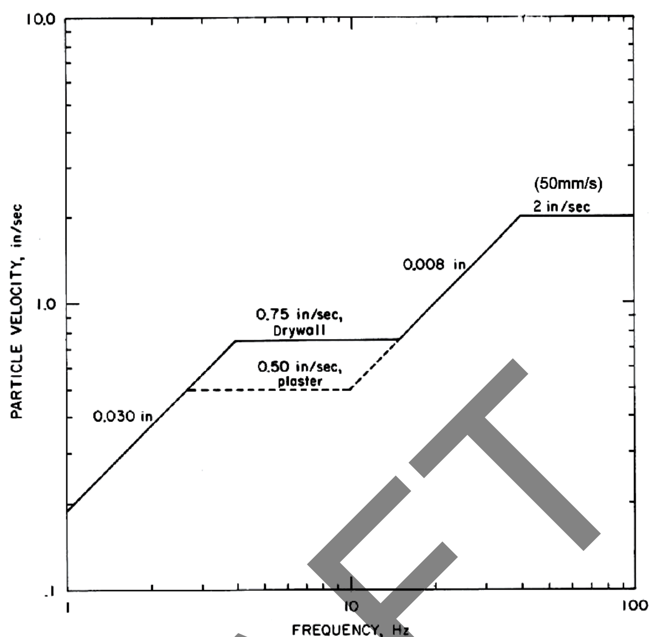

Figure 1 – USBM Z-Curve

It is an intrinsic nature of blast induced vibrations that these vibrations decrease with increasing distance. Under typical conditions, the vibration intensity decreases by two thirds of its previous value for every doubling of distance. That is to say that a peak particle velocity measurement of 100mm/s at a distance of 100 m from the blast location will have decreased to 33.3mm/s at a separation distance of 200m and 11.1 mm/s at a separation distance of 400m. While the nature of the transmitting medium (rock, earth, water) and presence of joint sets, fractures, faults and shear zones will all impact the rate of decay of the ground vibrations, the fact that intensities diminish with distance within consistent media is unavoidable. As such, the aforementioned vibration criteria as displayed graphically in the attachment can be readily extrapolated to buildings falling further from the blast site than the monitoring location.

There are a number of existing residential structures located along Road to Nowhere to the Southwest and the Plateau Subdivision to the West in the vicinity of the project footprint as shown in Table 1 above. The closest commercial structure is a water treatment and power plant located Southwest of the project footprint. Lastly, the Lake Geraldine Dam is located along the southwest shore of Lake Geraldine along Saputi Road.

With regards to vibration limits for adjacent residential and commercial structures, industry best practices would employ limits set out by the USBM Z-Curve noted above and Explotech supports the implementation of these limits for this scope of blasting work.

With regards to ground vibration limits for the Lake Geraldine Dam structure itself, it is widely accepted that concrete materials are able to endure vibrations many times greater than intensities required to crack weaker building components such as drywall and plaster. Crawford and Ward (1965) conducted tests to determine the peak particle velocities and dynamic strains necessary to crack cast-in-place concrete walls. They found that concrete walls did not crack until component peak particle velocities of 254 mm/s (10in/s) were reached at the wall center. Tart and Oriard et al, 1980, conducted tests to determine Peak Particle Velocity (PPV) levels necessary to generate cracks in concrete slabs. They found that the concrete slabs did not crack until particle velocities of 375 in/s (9525mm/s) were reached (Oriard 1999). Based on visual review of the photographs provided of the existing Geraldine Dam, the research discussed above, and Explotech's previous experience monitoring structures of a similar nature, Explotech would recommend a vibration limit of **100mm/s** at the Geraldine Dam. It should be noted that this recommended limit is extremely conservative, however given the distance between the required blasting and the dam, there is no benefit to applying a higher value.

At the time of authoring this report, we are unaware of the presence of any buried third party utilities. Should blasting be required in proximity to any third party utilities, blasting operations shall follow the rules and limits set out in the third parties blasting/vibration specifications (if applicable).

Air Overpressure and Applicable Limits

The damage potential associated with air blast overpressure (air blast) is recognized as being substantially limited when compared to ground vibrations. As such, most municipal construction projects typically do not impose a limitation upon measured air overpressures. While damage potential from air overpressure may be limited, the nuisance impact on surrounding residents can be extremely high and as such, a prudent monitoring program should always include air overpressure monitoring to assist in ascertaining the source of possible complaints. As with ground vibrations, overpressure energy dissipates with distance, although overpressure attenuation is far more dependent on environmental influences such as wind direction, temperature inversions and cloud cover which may drastically alter predictable attenuation patterns.

Air overpressures in the 141dB range are considered by most consultants to be the threshold level at which damage to windows in poor condition could possibly begin to occur, a level which is comparable to a wind gust of 65km/hr. Although such a wind is comparable to a strong air blast, its effects are not as noticeable to the layman observer.

Water Overpressure and Applicable Limits

The detonation of explosives in or near water produces compressive shock waves which initiate damage to the internal organs of fish in close proximity, ultimately resulting in the death of the organism. In an effort to alleviate adverse impacts on fish populations as a result of blasting, the Department of Fisheries and Oceans developed the *Guidelines for the Use of Explosives In or Near Canadian Fisheries Waters (1998)*. This publication establishes limits for water overpressure and ground vibrations which are intended to mitigate impacts on aquatic organisms while providing sufficient flexibility for blasting to proceed. Specifically, water overpressures are to be limited to 100kPa at the location of a live fish and ground vibrations are to be limited to 13mm/s at the location of an active spawning habitat.

Blast designs can be engineered to manage water overpressures by reducing the magnitude of water overpressures. Often external mitigation tools such as fish scare techniques using concrete vibrators or detonators, bubble curtains or even shot rock mattresses serve as tools to reduce water overpressure levels and reasonably mitigate the extent of fish casualties. Silt curtains are also effective tools for preventing silt contamination, mitigating some water overpressure levels and creating a fish exclusion zone by isolating the waterbody adjacent to blasting.

Predicted Ground Vibration, Air Overpressure, and Water Overpressure Levels

Ground Vibrations at Adjacent Receptors

Transmission and decay of ground vibrations can be estimated by the development of attenuation relations. These relations utilize empirical data measured during blasting operations in order to relate measured velocities at specific separation distances from the vibration source to calculate maximum particle velocities at variable distances from the source. Without any blasting having occurred on the site to date, localized effects of site-specific geological conditions and blast geometry cannot be accounted for. Accordingly, we have applied research performed by Dowding as a basis for the attenuation of ground vibrations.

The most commonly used formula for calculating PPV is known as the Bureau of Mines (BOM) formula or Propagation Law. This formula can calculate the PPV's at the closest structures from the blasting operations.

$$PPV = k\left(\frac{d}{\sqrt{w}}\right)^{e}$$

Where, PPV = the calculate peak particle velocity (mm/s)
K, e = site factors (1326, -1.38 from Dowding Research)
d = distance from receptor (m)
w = maximum explosive charge per delay (kg)

Applying multiple separation distances to the commercial structures yields the maximum explosives loads outlined in Table 2 below:

Distance	*Maximum Load per Delay to maintain 50mm/s (kg)*	**Maximum Load per Delay to maintain 100mm/s (kg)**
50m	21.6	59
100m	86	236
150m	194	531
200m	345	944
250m	540	1475
300m	778	2125
350m	1059	2892
400m+	1383	3777

Table 2: Maximum Load per Delay Allowable to Maintain Vibration Design Constraints

While Table 2 provides an initial estimate for the maximum explosive weight per delay to maintain compliance with vibration limits at adjacent structures, actual loads employed will be governed by the results obtained from the monitoring program implemented on this project. Should the above estimates prove to be over or under conservative the loads above can be modified along with parameters such as borehole size, pattern, among others, to bring vibration results back into compliance, or, increased to improve the production of the rock excavation.

Air Overpressure Levels at Adjacent Receptors

It is unusual for overpressure to reach damaging levels, and when it does, the evidence is immediate and obvious in the form of broken windows in the area. However, overpressure remains of interest due to its ability to travel further distances as well as cause audible sounds and excitation in windows and walls.

Air overpressure decays in a known manner in a uniform atmosphere, however, a uniform atmosphere is not a normal condition. As such, air overpressure attenuation is far more variable due to its intimate relationship with environmental influences. Air vibrations decay slower than ground vibrations with an average decay rate of 6dB(L) for every doubling of distance. Without any blasting having occurred on the site to date, localized effects of site-specific geological conditions and blast geometry cannot be accounted for. Accordingly, we have applied research performed by Oriard (2005) as a basis for the attenuation of air overpressure.

Air overpressure levels are analyzed using cube root scaling based on the following equation:

$$P = k\left(\frac{d}{\sqrt[3]{w}}\right)^{e}$$

Where, P = the peak overpressure level (dB(L))
K, e = site factors (1, -1.1 from Oriard Research)
d = distance from receptor (m)
w = maximum explosive charge per delay (kg)

Applying multiple separation distances yields the maximum explosives loads outlined in Table 3 below:

Distance	***Maximum Load per Delay to maintain 128dB(L) (kg)***
50m	3
100m	24
150m	80
200m	190
250m	370
300m	640
350m	1020
400+m	1520

Table 3: Maximum Load per Delay Allowable to Maintain an Air Overpressure of 128 dB(L)

We reiterate that air overpressure attenuation is far more variable due to its intimate relationship with environmental influences and as such, the equation employed is less reliable than that developed for ground vibration.

Table 3 is included strictly for informational purposes only. As mentioned previously in this report, Explotech does not recommend an overpressure limit be enforced for these blasting works but air overpressure monitoring should be performed regardless in order to quantify all derivatives of the blasting.

Water Overpressure and Spawning Bed Estimated Levels

As noted earlier, the DFO's *Guidelines for the Use of Explosives In or Near Canadian Fisheries Waters (1998)* provides guidelines for the mitigation of adverse impacts resultant from blasting operations in or near water bodies. Given the extensive number of waterbodies located in the project footprint and the fact that the distance to blasting operations will continually be changing as operations progress, a loading table has been provided to demonstrate the maximum loads allowable in order to maintain DFO limits for both water overpressure at the location of live fish and ground vibrations at adjacent spawning beds. These limits are only applicable at waterbodies that have been classified as fish bearing or spawning beds have been identified and blasting is occurring in a designated fish spawning window. Applying DFO's formulae to various separation distances yields the following result:

Separation distance between possible fish bearing waterbody and closest borehole (m)	Maximum recommended explosive load per delay (kg)
150	887
125	616
100	394
90	319
80	252
70	193
60	142
50	98.7
40	63.1
30	35.5
20	15.7
10	3.9

Table 4: Maximum Load per Delay Allowable to Maintain DFO limits of 100 kPa Water Overpressure at the location of live fish

In addition, applying the Bureau of Mines (BOM) formula or Propagation Law with the parameters described previously yields the following results to maintain the DFO 13mm/s vibration limit at an active spawning bed:

Separation distance between possible fish spawning location and closest borehole (m)	Maximum recommended explosive load per delay (kg)
300	110.4
250	76.7
200	49.1
175	37.5
150	27.6
125	19.1
100	12.3
90	9.9
80	7.8
70	6
60	4.4
50	3
40	1.95
30	1.1
25	0.75
20	0.5

Table 5: Maximum Load per Delay Allowable to Maintain DFO limits of 13mm/s at the Location of a Spawning Bed

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In an effort to mitigate adverse impacts of the blasting, the following parameters shall be adopted as a minimum:

- All blasting shall be performed in accordance with the *Guidelines for the Use of Explosives Near Canadian Fisheries Waters* as well as any project specific Permits and Authorizations issued;
- The use of ammonium nitrate fuel oil explosive (ANFO) shall not be permitted;
- Detonation wires and shock tubes shall be collected and removed following each blast;
- Continual efforts shall be employed to reasonably reduce fish mortality rates.

As an additional recommendation of this report, Explotech would suggest that water overpressure monitoring is performed whenever blasting operations encroaches within 30m of a waterbody that has been identified as containing live fish. Additionally, ground vibrations should be measured at the closest location that has been identified as a spawning bed in to confirm the DFO limit of 13mm/s is adhered to during periods of spawning.

Safety

All blasting operations shall be performed in complete compliance with applicable Federal, Provincial and Municipal Legislative Acts, Regulations and By-laws.

No explosives shall be stored on site overnight. All explosive products required for the day will be delivered each morning with any unused product transported off site for storage every evening in accordance with applicable Federal, Provincial and Municipal regulations. All shipments will be transported in accordance with Transport Canada regulations under the Transportation of Dangerous Goods Act. All blasting operations shall be carried out under the direct supervision of a competent blaster.

Prior to every blast, the Blaster will establish a Blast Exclusion Zone within which, at the sole discretion of the Blaster, no persons or equipment will be permitted. Guards will be posted as necessary to establish the limits of the Blast Exclusion Zone. Guards will be properly trained and competent in their duties and will be in direct contact with the blaster via radio or cell phone.

Once the Blast Exclusion Zone has been established and the Blaster has verified that the zone is clear, the Blaster shall sound a warning signal consisting of three (3) long whistles to signal that the blast will occur in one (1) minute. Following the one minute wait period, the Blaster will confirm with the guards that the Blast Exclusion Zone has not been breached. If it is safe to do so, the Blaster will fire the blast.

Following the blast, the Blast Exclusion Zone shall remain in place while the Blaster inspects the blast area. Once the Blaster has determined that the area is safe, he shall sound one long whistle to signify “all clear’ after which the Blast Exclusion Zone is released.

Matting of the blast shall be accomplished using rubber tire blast mats. Matting shall be applied at the blaster’s discretion in order to prevent flyrock from breaching the established exclusion zone, prevent damage to adjacent structures and equipment and prevent excessive material from entering adjacent fish habitat.

Vibration, Air Overpressure, Water Overpressure Monitoring and Reporting

Ground vibration, air overpressure and water overpressure monitoring shall be completed by a blast monitoring consultant specialist. Ground vibration and air overpressure shall be monitored through the employment of self-triggering digital seismographs capable of measuring ground vibrations in three mutually perpendicular planes and air overpressure in the linear scale. Geophones shall be capable of measuring vibrations up to 254mm/s at a frequency response of 2 – 250Hz and linear microphones shall be capable of measuring air overpressures up to 148dB(L) also at a frequency response of 2 – 250Hz.

Water overpressure monitoring shall be accomplished using hydrophone sensors installed at the closer of either the edge of an established fish exclusion zone or at the established setback distance from the blast site based on maximum load per delay when blasting encroaches within 30m of a waterbody containing live fish. The hydrophones shall be capable of measuring water overpressure up to 324kPa at sampling rates of 1024 samples per second (SPS).

All seismographs used on site shall be calibrated within 12 months of the date of blasting as applicable. Results from the monitoring program shall promptly be relayed to the blasting team for review to allow the blaster to have sufficient time to adjust blast parameters for the subsequent blast should the results necessitate changes.

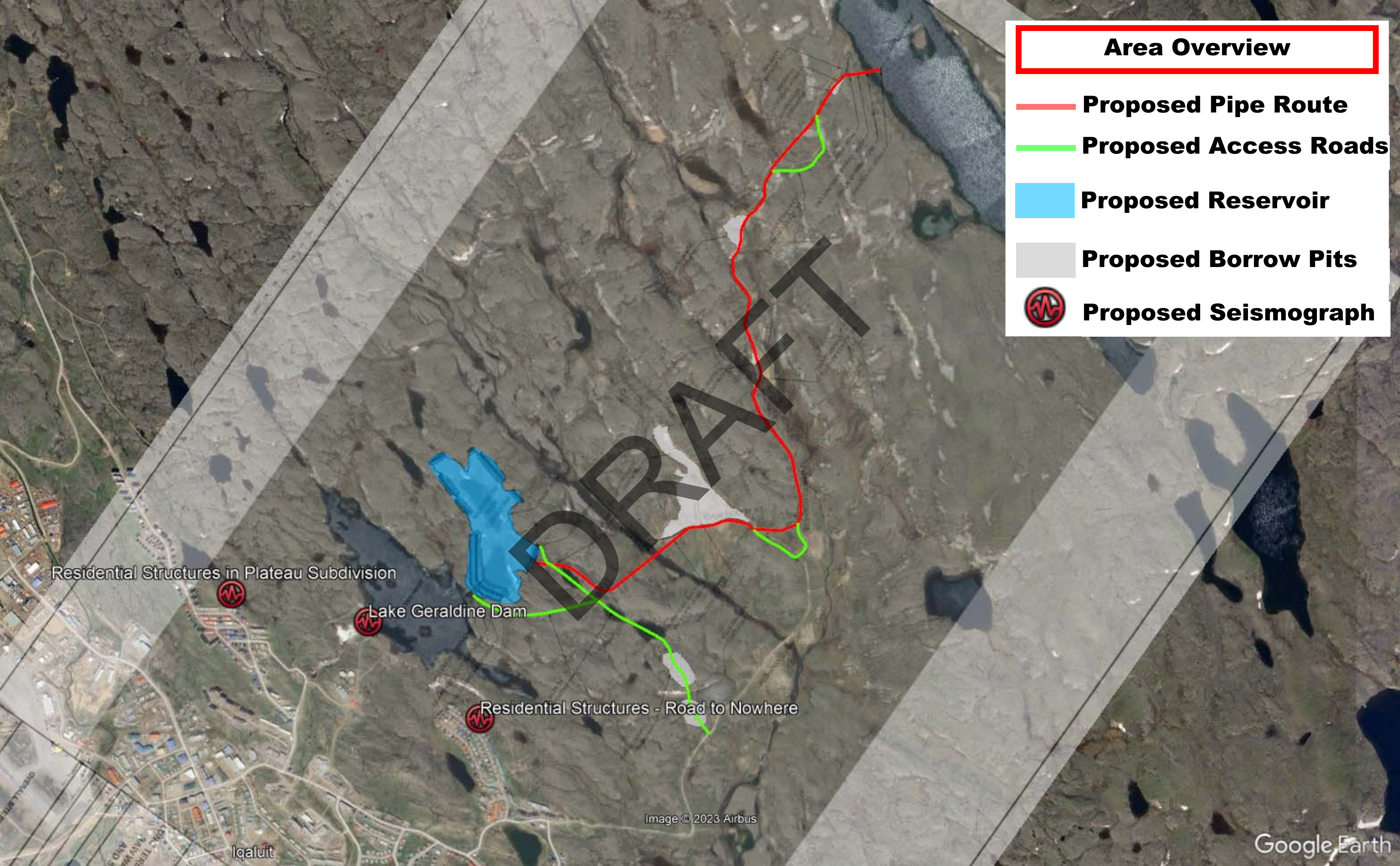
Based on the project footprint and surrounding structures, a seismograph should be installed at the properties to the South of the reservoir located on the Road to Nowhere , the properties located on in the Plateau Subdivision to the West of the reservoir, the Geraldine Dam and at the shoreline of the closest spawning bed to each individual blast during spawning windows (if applicable). As mentioned previously, when blasting encroaches within 30m of a waterbody containing live fish, water overpressure monitoring shall be performed at the closest portion of the waterbody to the blast.

Conclusion

Based on the presented methods of blasting and associated modeling untaken for this report, Explotech is of the opinion that blasting can be completed safely and within applicable limits to the project and adjacent infrastructure as stated in this report. We trust the foregoing presents the information required at this time but should you require any additional information or clarification, we remain available as required.

Michael Tobin P.Eng. (ON)
Explotech Engineering Ltd.

Rob Cyr, P.Eng.
Explotech Engineering Ltd.



Area Overview
Proposed Pipe Route
Proposed Access Roads
Proposed Reservoir
Proposed Borrow Pits
Proposed Seismograph
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Residential Structures in Plateau Subdivision
Lake Geraldine Dam
Residential Structures - Road to Nowhere
Image © 2023 Airbus
Iqaluit
Google Earth

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Specialists in Explosives, Blasting and Vibration
Consulting Engineers

Robert J. Cyr, P. Eng.

Principal, Explotech Engineering Ltd.

EDUCATION

Bachelor of Applied Science,
Civil Engineering, Queen's University

PROFESSIONAL AFFILIATIONS

Association of Professional Engineers of Ontario (APEO)
Association of Professional Engineers and Geoscientists of BC (APEG)
Association of Professional Engineers, Geologists and Geophysicists of Alberta
Association of Professional Engineers and Geoscientists of New Brunswick
Association of Professional Engineers of Nova Scotia
Association of Professional Engineers and Geoscientists Manitoba
Professional Engineers and Geoscientists Newfoundland and Labrador
Northwest Territories and Nunavut Association of Professional Engineers (NAPEG)
International Society of Explosives Engineers (ISEE)
Ontario Stone Sand & Gravel Association (OSSGA)
Surface Blaster Ontario Licence 450109

SUMMARY OF EXPERIENCE

Over thirty five years experience in many facets of the construction and mining industry has provided the expertise and experience required to efficiently and accurately address a comprehensive range of engineering and construction conditions. Sound technical training is reinforced by formidable practical experience providing the tools necessary for accurate, comprehensive analysis and application of feasible solutions. Recent focus on vibration analysis, blast monitoring, blast design, damage complaint investigation for explosives consumers and specialized consulting to various consulting engineering firms.

PROFESSIONAL RECORD

2001 – Present	-Principal, Explotech Engineering Ltd.
1996 – 2001	-Leo Alarie & Sons Limited - Project Engineer/Manager
1993 – 1996	-Rideau Oxford Developments Inc. – Project Manager
1982 – 1993:	-Alphe Cyr Ltd. – Project Coordinator/Manager

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Specialists in Explosives, Blasting and Vibration
Consulting Engineers

Mitch Malcomson, P.Eng.

Consulting Engineer, Explotech Engineering Ltd.

EDUCATION

Bachelor of Engineering,
Civil Engineering with Concentration in Business Management,
Carleton University

PROFESSIONAL AFFILIATIONS

Association of Professional Engineers of Ontario (APEO)
Association of Professional Engineers and Geoscientists of BC (APEG)
International Society of Explosives Engineers (ISEE)
Ontario Stone Sand and Gravel Association (OSSGA)

SUMMARY OF EXPERIENCE

A Consulting Engineer and Project Manager for Explotech Engineering Ltd., Mitch holds a Bachelor of Engineering degree from Carleton University in Civil Engineering with a Concentration in Business Management. Mitch has strong analytical, technical, business and leadership skills. As a Project Manager, Mitch is responsible for operational strategies, scheduling and contract procurement. As a Consulting Engineer, the technical responsibilities include detailed blast designs, blast investigations and reviews, implementation of vibration monitoring programs, development of monitoring equipment/ technologies and building assessments for construction and the drilling and blasting portions of mining, quarrying and construction projects across Canada.

PROFESSIONAL RECORD

2008 – Present - Consulting Engineer / Project Manager, Explotech Engineering Ltd.

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Specialists in Explosives, Blasting and Vibration
Consulting Engineers

Andrew Campbell, P.Eng.

Explotech Engineering Ltd.

EDUCATION & QUALIFICATIONS

Bachelor of Engineering,
Mechanical Engineering, Carleton University

Advanced and Expert (Industry) CadnaA Modelling
DataKustik, Mississauga, Ontario

PROFESSIONAL AFFILIATIONS

Association of Professional Engineers of Ontario (APEO)
International Society of Explosive Engineers (ISEE)

SUMMARY OF EXPERIENCE

An engineer working for Explotech Engineering Ltd., Andrew holds a Bachelor of Engineering degree in Mechanical Engineering and has strong analytical, technical, and interpersonal skills. A proven leader in collaborative environments, Andrew is comfortable managing projects, specifying details, and communicating internally and externally. With a focus on blast designs, blast impact analyses, noise monitoring and modelling, damage complaint investigations, vibration analysis, and blast monitoring, Andrew has applied these skills across Canada.

PROFESSIONAL RECORD

2018 – Present	- Engineer, Explotech Engineering Ltd.
2013 – 2018	- Technician / EIT, Explotech Engineering Ltd.
2012 – 2012	- Ride Technician, Canada's Wonderland

EXPLOTECH ENGINEERING LTD.
Ottawa ◆ Sudbury ◆ Toronto ◆ Halifax
WWW.EXPLOTECH.COM
1-866-EXPLOTECH

Specialists in Explosives, Blasting and Vibration
Consulting Engineers

Michael Tobin, P.Eng.

Explotech Engineering Ltd.

EDUCATION

Bachelor of Applied Science,
Geological Engineering, Queen’s University

PROFESSIONAL AFFILIATIONS

Association of Professional Engineers of Ontario (APEO)
International Society of Explosives Engineers (ISEE)

SUMMARY OF EXPERIENCE

An engineer working for Explotech Engineering Ltd., Michael holds a Bachelor of Applied Science degree from Queen’s University in Geological Engineering. Michael has strong analytical, technical, and interpersonal skills. Recent projects have focused on blast monitoring, vibration analysis, job estimation, damage complaint investigation and blast design.

PROFESSIONAL RECORD

2021 – Present - Engineer, Explotech Engineering Ltd.

2017 – 2021 - Technician, Explotech Engineering Ltd.